Engagement Opportunities in NASA STEM 2023 (EONS-2023)
NASA Research Announcement (NRA)
MUREP Space Technology Artemis Research (M-STAR)
Number: NNH23ZHA001N-MSTAR

Title: The Research and Development of Extravehicular Activity Gait Assist Device

Institution: Cankdeska Cikana Community College

City/State: Fort Totten, ND

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Summary: Cankdeska Cikana is a Tribal college serving the Spirit Lake Nation, including the Dakota/Lakota, Sisseton, Wahpeton, and Yanktonai peoples. This college has an advanced manufacturing lab, teaching state-of-the-art manufacturing techniques at the very edge of its infrastructural capabilities. Nick Bitner, a faculty member at Cankdeska Cikana , has designed a device for extravehicular activity (EVA) boots. It is called the Mapi Hapa (MH), Spirit Lake Dakota, for "Sky Shoe." This device is designed to provide a biomechanical enhancement to current EVA boots.

EVA boots designed for the Artemis program will require rigid soles. This design aspect is due to a thermal insert required for the frigid surface at the lunar south pole. Ankle flexion has been a concern of suit designers. Boots planned for the XEmu have an articulating ankle joint allowing flexion and extension (Boppana & Anderson, 2022). However, range of motion inhibition at the metatarsophalangeal (MTP) joint remains. Dorsi flexion of the MTP joint allows rolling of the foot during the gait swing phase, essentially reducing the length of the foot lever arm and reducing the force necessary to roll the foot into the toe-off position. Plantar flexion, additionally, facilitates impulse during the gait cycles and the trunk's swing phase initiation and forward acceleration (Stokes, 2007).

The MH is a 3D printable device that attaches to the exterior of an EVA boot. The MH mimics the MTP's dorsi and plantar flexion action while allowing the EVA boot to remain rigid. The MH accomplishes this by storing kinetic energy during the gait loading phase. This energy storage also reduces the MH's height, mimicking the MTP joint's actions during dorsi flexion. At toe-off, the MH discharges the stored kinetic energy mimicking MTP plantar flexion. Through these actions, MH provides the forces traditionally generated by the MTP while allowing the boot to remain completely rigid. Nick Bitner collaborating with Jesse Rhoades at the University of North Dakota, conducted initial ground reaction force and high-speed camera testing of an MH prototype. These tests demonstrated the mimicked forces of plantar and dorsi flexion at the MTP joint while attached to a rigid boot, providing proof of concept.

The proposed M-Star project develops the MH into an advanced low-temperature prototype. The development concentrates on optimizing mechanical design and construction materials. Cankdeska Cikana students, through this project, have authentic STEM experiences,

collaborating with EVA suit experts on designs and learning the interpretation of testing data to inform the engineering design process. Students at Cankdeska Cikana participate in this project at three levels; first, Cankdeska Cikana funds interns at NASA. Upon their return, these interns share their knowledge and experiences through work as laboratory technicians and provide mentorship to future interns. Second, more Cankdeska Cikana students work directly as lab technicians on the MH prototypes, learning through direct collaboration with experts. Third, students will have coursework in the design and manufacturing process of the MH. A final benefit for Cankdeska Cikana and its future students is access to a wide variety of state-of-the-art manufacturing equipment and knowledge made possible by funding provided by this project.

Upon completing this project, Cankdeska Cikana students have received real-world experience working with state-of-the-art equipment and experts in spacesuits and 3D printing design. Cankdeska Cikana's advanced manufacturing program has also increased its design and manufacturing educational capabilities. Finally, this project produces advanced low-temperature prototypes of the MH, which may improve the health and well-being of future lunar astronauts.